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COMPUTER aRCHITECTURE AND TECHNOLOGY cONVERGENCE

Assignment

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## Q1: Binary Arithmetic:

Feel free to use any resources you need for the tasks below, but make sure to show workings.

### Q1.1. Question

Add 11011 to 1011. Show your work (in particular, show where you get carries, and where you don't). You can check your work by translating the numbers into decimal, but I want to see the addition algorithm in base 2 instead of base ten.

### Q1.1. **Answer**

Binary Addition: Verification:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carry |  | 1 |  | 1 | 1 |  |
|  |  | 1 | 1 | 0 | 1 | 1 |
|  |  |  | 1 | 0 | 1 | 1 |
| Sum | 1 | 0 | 0 | 1 | 1 | 0 |

|  |  |
| --- | --- |
| Binary | Decimal |
| 11011 | 16+8+0+2+1 = 27 |
| 1011 | 8+0+2+1 = 11 |
| 100110 | 32+0+0+4+2 = 38 |

### 

### Q1.2. Question

Rewrite the following base-10 numbers as 8-bit two's complement integers: -31, & -59.

### Q1.2. **Answer**

**Step 1**: Binary Representation of 31 and 59

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|  |  |  |  |  |  |  |  |  |  |
| 31 |  | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 59 |  | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |

**Step 2**: Invert the binary digits

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 31 |  | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 59 |  | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |

**Step 3**: Add 1 to the result

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carry |  |  |  |  |  |  |  |  |  |
|  |  | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
|  |  |  |  |  |  |  |  |  | 1 |
| -31 |  | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carry |  |  |  |  |  |  |  |  |  |
|  |  | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
|  |  |  |  |  |  |  |  |  | 1 |
| -59 |  | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |

### Q1.3. **Question**

What does the bit pattern 11101001 represent if you interpret it as an 8-bit two's complement integer?

### Q1.3. **Answer**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Given Number |  | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| Inversion |  | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |

Step 1: Invert the original Number

Step 2: Add 1 to the inverted number

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carry |  |  |  |  |  |  |  |  |  |
|  |  | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
|  |  |  |  |  |  |  |  |  | 1 |
|  |  | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |

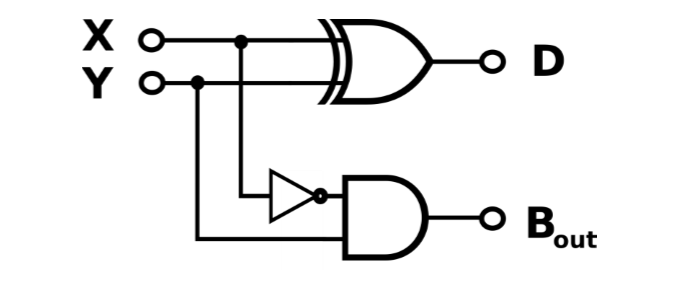
Step 3: Calculate the Decimal Number

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|  |  |  |  |  |  |  |  |  |  |
| 23 |  | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |

Since the original number was negative, the final result is -23.

### Q1.4. Question

Draw up the truth table for the circuit below (inputs are X and Y and outputs are B and D). From observing the result, what function do you think this circuit performs?



### Q1.4. Answer

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| XOR  (X) | XOR  (Y) | XOR - Output  D | AND  (X’) | AND  (Y) | Bout |
| 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 0 |

Truth Table

|  |  |  |  |
| --- | --- | --- | --- |
| X | Y | D | Bout |
| 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 |

### Q1.5. Question

Draw the circuit diagram for the Boolean logic equation: (AB + C)D

### Q1.5. Answer

